DETERMINATION OF THE AVERAGE CYCLONIC FLOW ANGLE IN EXHAUST STACKS, DUCTS, AND VENTS

Purpose

This Air Quality Group procedure provides instruction for the measurement of average cyclonic flow angle (α or yaw angle) in LANL exhaust stacks, ducts, and vents using EPA Reference Method 1.

Scope

This procedure applies to the measurement of average cyclonic flow angle in all LANL exhaust stacks, ducts, and vents for the ESH-17 Rad-NESHAP project.

In this Procedure

Hazard Control Plan

The non-office work steps in this procedure are not performed by ESH-17 personnel; thus no ESH-17 HCP has been prepared. It is the responsibility of the JCNNM supervisors of personnel performing this process to ensure all applicable hazards analyses have been performed according to applicable requirements.

Signatures

Prepared by: Victor Martinez, ESH-17	Date: 1/3/2000
Approved by: Scott Miller, ESH-17 Rad-NESHAP Project Leader	Date: 1/4/2000
Approved by: Terry Morgan, ESH-17 Quality Assurance Officer	Date: 1/4/2000
Approved by: Doug Stavert, ESH-17 Group Leader	Date: 1/4/2000

General information

Attachments

This procedure has the following attachments:

Number	Attachment Title	No. of pages
1	Cyclonic Flow Angle Measurement Form (Form 1-M)	1
2	Cyclonic Measurement Input Form (Form 1-R)	1
3	Cyclonic Measurement Input Form (Form 1-S)	1
4	Cyclonic Measurement Input Continuation Form (Form 1-C)	1

History of revision

This table lists the revision history and effective dates of this procedure.

Revision	Date	Description of Changes
0	4/24/98	New document.
1	1/6/00	Restructured text and attachments and revised many steps.

Who requires training to this procedure?

The following personnel require training before implementing this procedure:

- JCNNM technicians and staff members who perform or support exhaust stack, duct, or vent cyclonic flow measurements for the ESH-17 Rad-NESHAP project
- ESH-17 technicians and staff members who support exhaust stack, duct, or vent cyclonic flow measurements for the Rad-NESHAP project

Training method

The training methods for this procedure are:

- **on-the-job** training for technicians and staff members *performing* cyclonic flow measurements and
- "**self-study**" (reading) for technicians and staff members *supporting* cyclonic flow measurements and for those previously trained to Revision 0 of this procedure.

Annual retraining is required and will be by "self-study" (reading). Training is documented in accordance with the procedure for training (ESH-17-024).

General information, continued

Prerequisites

In addition to training to this procedure, the following training or surveillance programs are also required for technicians and staff members prior to performing flow measurements:

- Radiological Worker II Training
- PU access list
- ESH-5 full face respirator fitting and training program (when required)
- Site-specific training as required for each facility
- ESH-17-024, "Personnel Training"
- ESH-17-026, "Deficiency Reporting and Correcting"
- ESH-17-127, "Determination of Stack Gas Velocity and Flow Rate in Exhaust Stacks, Ducts, and Vents

Recommended training

The following training is recommended, but not required:

- Tritium Safety
- Plutonium Safety
- Beryllium Health Hazards
- Hazard Communication Introduction

Definitions specific to this procedure

AHA: Activity hazard analysis

EDM: Electronic Digital Manometer

FMU: Facility Management Unit

LIR: Laboratory Implementation Requirement

NIST: National Institute of Standards and Technology

General information, continued

References

The following documents are referenced in this procedure:

National Codes and Standards

- 40 CFR 61 Subpart H, "National Emission Standards for Emissions of Radionuclides Other Than Radon From Department of Energy Facilities"
- Method 1: EPA 40 CFR 60 Appendix A Test Method, "Sample And Velocity Traverses For Stationary Sources"
- Method 1A: EPA 40 CFR 60 Appendix A Test Method, "Sample And Velocity Traverses For Stationary Sources With Small Stacks Or Ducts"
- Method 2: EPA 40 CFR 60 Appendix A Test Method, "Determination Of Stack Gas Velocity And Volumetric Flow Rate (Type S Pitot Tube)"
- Method 2C: EPA 40 CFR 60 Appendix A Test Method, "Determination Of Stack Gas Velocity And Volumetric Flow Rate In Small Stacks Or Ducts (Standard Pitot Tube)"

Los Alamos National Laboratory Requirements

- LIR 230-03-01, "Facility Management Work Control"
- LIR 402-10-01, "Hazard Analysis and Control for Facility Work"
- LIR 402-704-01, "Contamination Control"

ESH-17 Procedures

- ESH-17-024, "Personnel Training"
- ESH-17-026, "Deficiency Reporting and Correcting"
- ESH-17-127, "Determination Of Stack Gas Velocity and Flow Rate in Exhaust Stacks, Ducts, and Vents"

Manufacturer's Literature

- Refer to the manufacturer's literature for each instrument

Note

Actions specified within this procedure, unless preceded with "should" or "may", are to be considered mandatory guidance (i.e., "shall").

Work control

General

JCNNM coordinates all work in support of LANL's exhaust stack flow measurement program with the appropriate facility management unit in accordance with LIR 230-03-01, "Facility Management Work Control."

Work orders

ESH-17 will issue, and fund annually, a work order to capture costs for the cyclonic flow measurements. All cyclonic flow measurements will be performed and charged to separate work orders. ESH-17 will submit a work order for each measurement (or group of measurements within one building and FMU) to the appropriate facility management unit for review and processing.

Hazard analysis

It is the responsibility of the **JCNNM supervisors** of personnel performing this process to ensure all applicable hazards analyses have been performed according to applicable requirements (e.g., LIR 402-10-01, "Hazard Analysis and Control for Facility Work"). The **foreman** refers to the activity hazard analysis (AHA) to know which personal protective equipment must be worn during maintenance, repair, and installation work.

Facility check-in and check-out

Special check-in and check-out procedures must be followed for working in certain facilities. The appropriate **work crew foreman** will ensure that all check-in and check-out procedures are followed and that the work crew is briefed prior to being dispatched to perform the work.

Measurement frequency

Cyclonic flow measurements are performed at a site to determine if it meets EPA Reference Method 1's criteria for Method 2 flow measurements and/or sample collection. These measurements are generally performed only one time at a site.

Safety and hazard analysis

ES&H hazard screening

As required by LIR 230-03-01, "Facility Management Work Control," **facility coordinators** (not JCNNM) perform an ES&H hazard screening in accordance with LIR 402-10-01, "Hazard Analysis and Control for Facility Work."

Potential hazards to consider

The following types of hazards may be present during cyclonic flow angle measurements and must be addressed during the hazard analysis:

- radiation
- chemical emissions
- rotating machinery
- heights (e.g., roofs, scaffolding, bucket truck, etc.)
- weather (e.g., lightning, snow, ice, etc.)
- noise
- heat exposure
- falling objects
- compressed air

Radiological hazards

Before scheduling access to roof tops or opening of stack measurement ports, determine if planned laboratory processes could be producing unusual radiological hazards during the time maintenance personnel plan to be working with the stacks.

Potentially contaminated equipment

Equipment used to measure cyclonic flow angles in potentially radioactive stacks must be cleared by the site radiological control technician in accordance with facility requirements and LIR 402-704-01, "Contamination Control." If radioactive contamination is detected, trained and qualified personnel must decontaminate the unit before it may be removed from the site.

Personal protection equipment

Safety shoes and safety glasses must be worn while performing all cyclonic flow angle measurements. The following additional personal protective equipment may be required:

- hard hat
- hearing protection
- anti-contamination clothing including rubber gloves
- respirator

Permits

All permits (e.g., radiation work permits) must be issued before work is released to the crafts.

Equipment specifications

Acceptable equipment

Specifications for equipment to be used to perform this procedure are given below. Other equipment meeting these specifications may be acceptable. **ESH-17 must obtain approval from EPA for substitute equipment not specified below.**

Type-S pitot tube

The Type-S pitot tube must be constructed of metal tubing (e.g., stainless steel) meeting the dimensional tolerances in EPA Reference Method 2 (ESH-17-127). An identification number must be assigned to the pitot tube and be permanently marked or engraved on the body of the tube.

Differential pressure gauge

An oil-gauge manometer or equivalent device (EDM) must be used. If a device other than an oil-gauge manometer is used (such as an EDM), its calibration must be checked after each test series.

Special tools

The following special tools are needed to perform this procedure:

- pitot tube level.
- pitot tube square
- protractor/angle finder

Equipment calibration

Equipment calibration requirements

All equipment used to perform this procedure must meet the calibration requirements described below.

Type-S pitot tube

The Type-S pitot tube must be calibrated according to the requirements of EPA Reference Method 2 (see ESH-17-127, Attachments 1, 2, and 3).

Electronic Digital Manometer

An Electronic Digital Manometer (EDM) may be used (instead of an oil-gage manometer) to measure the cyclonic flow angle in the stacks and must be calibrated annually by the Standards and Calibration Group (ESA-MT) or the manufacturer. Calibration must be traceable to NIST standards.

Prior to each use, it is highly recommended that a calibration check be performed on the EDM against an oil-gage manometer in the shop wind tunnel. Compare the VP readings of the EDM with those of an oil-gage manometer at a minimum of three points (high-medium-low). If, at each point, the values of VP, as read by the EDM and oil-gage manometer, agree to within 5 percent, consider the EDM to be in proper calibration and can be used for field measurements.

Measuring cyclonic flow

Background

In most stationary sources, the direction of the stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations that tend to induce swirling.

This procedure may only be used at measurement sites that meet the criteria of EPA Reference Method 1 or 1A (the site is at least 2 duct diameters downstream and ½ duct diameter upstream from a flow disturbance). Locations for performing measurements are identified by ESH-17.

Exhaust stack measurement location (i.e., profile location)

ESH-17 will specify the location on the exhaust stack to perform cyclonic flow angle measurements. In addition, ESH-17 will specify the number of traverses, the number of measurement points, and their spacing along each traverse.

The measurement location, the number of traverses, and the number of measurement points along each traverse defines the profile. ESH-17 will identify each profile with a unique number.

Field measurement forms

Record all measurement field data on the Cyclonic Flow Angle Measurement Form (Attachment 1, Form 1-M) and the appropriate Cyclonic Measurement Input Form (Attachments 2 or 3), depending on whether the stack is round (Form 1-R) or rectangular (Form 1-S). A continuation form may also be used (Form 1-C).

Record all entries in ink. Correct any errors by striking through the erroneous entry with a single line and annotating the correct information in an empty space directly adjacent to the error. Initial the correction.

Field conditions

Only perform cyclonic flow angle measurements when an exhaust stack, duct, or vent is exhausting ambient air from a laboratory or facility.

Measuring cyclonic flow, continued

Steps to perform measurements

To measure cyclonic flow in a stack, duct, or vent, perform the following steps:

Step	Action
Determining the location for performing measurements	
1	Obtain the location on the stack or duct from ESH-17 before performing the measurement. The location is identified by the profile measurement number.
Preparing measurement input forms	
2	Record the TA, building, exhaust stack (ES) ID Number and exhaust fan(s) numbers on the top of the Cyclonic Flow Angle Measurement Form (Attachment 1, "Form 1-M"). Also record the profile number and the fan configuration number. The ES ID Number is the eight digit number, TA-BLDG-ES, with leading zeros.
3	Record the date of the measurements on the top of the Cyclonic Flow Angle Measurement Form.
Preparing equipment	
4	Verify that the EDM and type-S pitot tube calibration certifications have not expired. Record the following in section 1 of the Cyclonic Flow Angle Measurement Form (Form 1-M): • type of manometer (e.g., EDM) • serial number • calibration expiration date
5	Select the correct Type-S pitot tube for the stack(s) to be analyzed. The tip of the pitot tube to be used must be free of any damage (see ESH-17-127, Attachment 1). The selected pitot tube should be long enough to reach all traverse points through the cross-section of the stack(s). • Calculate the distances from the centerline of the pitot tube nozzle to each traverse point and mark the pitot tube with a felt-tipped pen so that the pitot can be correctly positioned from the hole in the stack wall to each traverse point. Have a second qualified stack measurement craftsman independently verify the markings. • Record the serial number of the type-S pitot tube(s) to be used in section 1 of the Cyclonic Flow Angle Measurement Form (Form 1-M).

Measuring cyclonic flow, continued

Step	Action
Verifying exhaust system is exhausting ambient air and inspecting system	
6	Check with Facility Management before starting flow measurements to verify that the stack is not exhausting radioactive or other hazardous process exhaust. Only perform cyclonic flow angle measurements when an exhaust stack, duct, or vent is exhausting ambient air from a laboratory or facility.
7	Before measuring the cyclonic flow angles, inspect the exhaust system, i.e. fan(s), dampers, etc. Record, in section 2 of the of the Cyclonic Flow Angle Measurement Form, any unusual conditions or variations observed in the configuration of the exhaust system during the inspection. Report these findings to the Facility Management Unit before leaving the work area. **If conditions present may present a hazard, DO NOT perform the flow measurements. Report the conditions to the FMU and reschedule the flow measurement after the hazard has been mitigated.**
Setting up and adjusting equipment	
8	Connect the manometer to the Type-S pitot tube using capillary tubing in the manner described in the manufacturer's instructions. Record a check mark in the appropriate box in section 3 of the Cyclonic Flow Angle Measurement Form (Form 1-M).
9	Optional but recommended: Perform a leak check test on the capillary tubing installed between the EDM and the pitot tube. The capillary tubing must be air tight, holding a pressure of 3 inches of H_2O for 15 seconds. **Do Not Pressurize The Tube By Mouth!** 1. Blow (or pump) dry air into the impact opening (the tip facing the air stream) until at least 3 inches of H_2O pressure registers on the EDM. Close off the tube. The pressure reading should remain stable for at least 15 seconds. 2. Next, pull a 3 inch vacuum to test the static pressure side. Again, the negative pressure reading should remain stable for at least 15 seconds after the tube is closed. If the system does not pass the leak test, correct the problem before performing the cyclonic flow measurements.
10	Adjust the EDM sensitivity to the gauge setting recommended by the manufacturer for the pressure anticipated. Record a check mark in the appropriate box in section 3 of the Cyclonic Flow Angle Measurement Form.

Measuring cyclonic flow, continued

Step	Action
11	Zero the manometer. Because the manometer zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record a check mark in the appropriate box in section 3 of the form.
Performing traverse readings	
12	Don all required PPE as specified in the RWP and any other applicable work permits.
13	Record the time of the first reading in section 4 of the Cyclonic Flow Angle Measurement Form.
14	Remove the measurement hole plugs as each hole is used and insert the Type-S pitot tube.
15	Seal the opening between the stack wall and the pitot tube
16	Verify with a level and square that the S-type pitot tube is parallel to the cross-sectional plane of the stack and that the plane of the face opening of the pitot tube is perpendicular to the stack cross-sectional plane. The level and square tool must be attached parallel to the center line axis of the stack. Verify angle finder is at 0° in this configuration. **IMPORTANT: The pitot tube MUST be level and the face openings MUST be parallel to the center line of the stack.** The pitot tube is in the 0° reference position.
17	Record the differential pressure (Δp) at the 0° reference position on the appropriate Cyclonic Measurement Input Form (see Attachments 2 - 4). If the Δp reading is not zero, then rotate the pitot tube (up to $\pm 90°$ yaw angle) until a null reading is obtained. Using a protractor or other type of angle finder, carefully determine and record the value of the rotation angle to the nearest degree.
18	Repeat Steps 16, 17 and 18 at all traverse points specified by EPA Reference Method 1 or 1A (provided by ESH-17). Reinsert the hole plug after each traverse has been completed. Record a check in the box in section 7 of the Cyclonic Flow Angle Measurement Form
19	Record the time of the last reading in section 4 of the Cyclonic Flow Angle Measurement Form.

Measuring cyclonic flow, continued

Step	Action
20	Perform a post-measurement leak check on the capillary tubing installed between the EDM and the pitot tube. The capillary tubing must be air tight, holding a pressure of 3 inches of H_2O for 15 seconds. **Do Not Pressurize The Tube By Mouth!** • Blow (or pump) dry air into the impact opening (the tip) until at least 3 inches of H_2O pressure registers on the EDM. Close off the tube. The pressure reading should remain stable for at least 15 seconds. • Next, pull a 3-inch vacuum to test the static pressure side. Again, the negative pressure reading should remain stable for at least 15 seconds after the tube is closed. If the system does not pass the leak test, void the measurement. Correct and document the problem in section 6 of the Cyclonic Flow Angle Measurement Form (Form 1-M). Repeat the cyclonic flow measurements.
21	Record any condition(s) that may affect the accuracy or the validity of the measurement data in section 6 of the Cyclonic Flow Angle Measurement Form.
22	Inspect the work site to be sure all equipment and tools have been collected.
23	If a manometer (EDM) other than an oil-gage manometer was used, then a post-measurement verification must be performed. Verify the accuracy of the reading on the EDM against another calibrated manometer (or an oil-gage manometer). The readings should not deviate more than ±5% from the instrument that was used in the field. The pressure readings must be verified in a wind tunnel at three different pressures representing the approximate range of the readings (high-mid-low) encountered in the field. Use the collected cyclonic data to determine the pressure range. In addition, the static pressure must be measured at each of the three pressure readings. The static pressure reading must not vary by more than 5%. Record data in Section 8 and check box.
Completing and submitting forms	
24	Complete, sign, and forward the forms to the JCNNM mechanical engineer for the calculation and/or verification of the cyclonic flow angle measurements.

Performing calculations

Verify data collection

The **JCNNM mechanical engineer** verifies that the procedural steps were followed, data are properly recorded and within range expected for that parameter, and (if data were transcribed from a field work sheet to a final copy of the form) there are no transcription errors. Document the performance of these steps by signing the forms in the space "JCNNM QA check by:"

Performing cyclonic flow angle calculations

The **JCNNM mechanical engineer** performs calculations in accordance with the instructions below. Retain at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation. Record the results on the forms in the appropriate spaces. Sign the bottom of the forms in the space "Calculations by:" to indicate that all data have been reviewed and verified as described in the block above.

Calculate average rotation angle

Average rotation angle: $\alpha = \frac{\sum_{i=1}^{i=n} \alpha_i}{n}$

where:

i = the traverse number
n = the total number of measurement points

Acceptable rotation angle

α must be less than or equal to 20° for the site to be acceptable for either flow measurements or sample collection.

Forward forms to ESH-17

Provide ESH-17 with the original cyclonic flow measurement forms [Attachment 1 (Form 1-M) and Attachments 2, 3, or 4 if used] **within two weeks** of performing flow measurements.

Reviewing and verifying calculations

Review and verify calculations

The **ESH-17 engineer** receives the forms from the JCNNM mechanical engineer and performs a detailed review and verification of all data and calculations. Sign the forms in the space "ESH-17 review and approval by:" to indicate approval of data and calculation results.

Submit records

The **ESH-17 engineer** files the forms in the ESH-17 Records Center.

Records resulting from this procedure

Records

The following records generated as a result of this procedure are to be submitted as records **within two weeks of completion** to the group records coordinator:

- Attachment 1 (Form 1-M)
- At least one of the following forms, as appropriate:
  - Attachment 2 [Cyclonic Measurement Input Form (Form 1-R)]
  - Attachment 3 [Cyclonic Measurement Input Form (Form 1-S)]
- Attachment 4 [Cyclonic Measurement Input Continuation Form (Form 1-C)], if used

Work order documents maintained by JCNNM

Record files must be established and maintained by JCNNM to support the ESH-17 Rad-NESHAP project flow measurement program.

Work records must be maintained by JCNNM. Records to be filed and maintained in shop files for a minimum of two years include, as a minimum, copies of the following documentation.

- hazard analysis (e.g., AHA)
- ESH reviews

ESH-17, Air Quality

Cyclonic Flow Angle Measurement Form (Form 1-M)

Page 1 of 1

This form is from ESH-17-128

TA/Building/ES _____-_____-_____ FE(s) _____

Profile Measurement Number _____

Measurement Date _____/_____/_____ Fan Exhaust Configuration _____

1. Equipment used and calibration

Manometer _____ Serial Number _____ Calibration Expiration ____/____/____

Pitot Tube Type-S Serial Number _____

☐ Traverse spacing pre-marked on pitot tube / pitot tube inspected

2. Location inspection

Location Comments: _____

3. Equipment setup

☐ Connect manometer to tubing ☐ Pre-test leak test performed

☐ Adjust manometer sensitivity ☐ Level and zero the manometer

4. Perform traverse readings (record velocity pressure and angle)

Run Start Time: _____ Run Complete Time: _____

5. Post measurement leak test (3" wg)

☐ successful ☐ measurement voided

6. Condition which might affect measurements

_____

7. Holes covered

☐ Complete

8. Manometer Verification

☐ Manometer verification passed (within 5%) ☐ Manometer verification not required.

Test Number	Test Velocity (fpm)	Velocity Pressure (inches wg)			Static Pressure (inches wg)		
		Manometer	Reference	% Difference	Manometer	Reference	% Difference
1							
2							
3							

Measurements by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

JCNNM QA check by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

ESH-17, Air Quality

Cyclonic Measurement Input Form (Form 1-R)

(2 x 12 Round Stack or Duct)

Page 1 of 1

This form is from ESH-17-128

TA/Building/ES _____-_____-_____

Measurement Date _____/_____/_____

Measurement Traverse A				Measurement Traverse B			
Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
A1				B1			
A2				B2			
A3				B3			
A4				B4			
A5				B5			
A6				B6			
A7				B7			
A8				B8			
A9				B9			
A10				B10			
A11				B11			
A12				B12			
Sum α for A1 - A12				Sum α for B1 - B12			
Average α is							

Flow measurements were made in accordance with ESH-17-128.
Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17, Air Quality

Cyclonic Measurement Input Form (Form 1-S)

(6 x 5 Rectangular Stack or Duct)

Page 1 of 1 — This form is from ESH-17-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
A1				B1			
A				B2			
A3				B3			
A4				B4			
A5				B5			
C1				D1			
C2				D2			
C3				D3			
C4				D4			
C5				D5			
E1				F1			
E2				F2			
E3				F3			
E4				F4			
E5				F5			
Sum of α angles A/C/E				Sum of α angles B/D/F			
Average α angle is							

Flow measurements were made in accordance with ESH-17-128.

Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17, Air Quality

Cyclonic Measurement Input Continuation Form (Form 1-C)

Page 1 of 1 This form is from ESH-17-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Measurement Traverse ____				Measurement Traverse ____			
Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
Sum of α angles				Sum of α angles			
Average α angle is							

Flow measurements were made in accordance with ESH-17-128.
Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Cyclonic Flow Angle Measurement Form (Form 1-M)

This form is from ESH-17-128

TA/Building/ES _____-_____-_____ FE(s) _____

Profile Measurement Number _____

Measurement Date _____/_____/_____ Fan Exhaust Configuration _____

1. Equipment used and calibration

Manometer _____ Serial Number _____ Calibration Expiration ____/____/____

Pitot Tube Type-S Serial Number _____

☐ Traverse spacing pre-marked on pitot tube / pitot tube inspected

2. Location inspection

Location Comments: _____

3. Equipment setup

☐ Connect manometer to tubing ☐ Pre-test leak test performed

☐ Adjust manometer sensitivity ☐ Level and zero the manometer

4. Perform traverse readings (record velocity pressure and angle)

Run Start Time: _____ Run Complete Time: _____

5. Post measurement leak test (3" wg)

☐ successful ☐ measurement voided

6. Condition which might affect measurements

_____

7. Holes covered

☐ Complete

8. Manometer Verification

☐ Manometer verification passed (within 5%) ☐ Manometer verification not required.

Test Number	Test Velocity (fpm)	Velocity Pressure (inches wg)			Static Pressure (inches wg)		
		Manometer	Reference	% Difference	Manometer	Reference	% Difference
1							
2							
3							

Measurements by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

JCNNM QA check by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

Cyclonic Measurement Input Form (Form 1-R)

(2 x 12 Round Stack or Duct)

This form is from ESH-17-128

TA/Building/ES _____-_____-_____

Measurement Date _____/_____/_____

Measurement Traverse A				Measurement Traverse B			
Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
A1				B1			
A2				B2			
A3				B3			
A4				B4			
A5				B5			
A6				B6			
A7				B7			
A8				B8			
A9				B9			
A10				B10			
A11				B11			
A12				B12			
Sum α for A1 - A12				Sum α for B1 - B12			
Average α is							

Flow measurements were made in accordance with ESH-17-128.
Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Cyclonic Measurement Input Form (Form 1-S)

(6 x 5 Rectangular Stack or Duct)

This form is from ESH-17-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
A1				B1			
A				B2			
A3				B3			
A4				B4			
A5				B5			
C1				D1			
C2				D2			
C3				D3			
C4				D4			
C5				D5			
E1				F1			
E2				F2			
E3				F3			
E4				F4			
E5				F5			
Sum of α angles A/C/E				Sum of α angles B/D/F			
Average α angle is							

Flow measurements were made in accordance with ESH-17-128.

Measurements by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____

Signature Print name Z-Number Date

Cyclonic Measurement Input Continuation Form (Form 1-C)

 This form is from ESH-17-128

TA/Building/ES _____-_____-_____ Measurement Date _____/_____/_____

Measurement Traverse ____				Measurement Traverse ____			
Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0	Point	Spacing (nearest 1/8 in)	Velocity Pressure at $\alpha = 0°$ (in H_2O)	Angle α @ VP=0
Sum of α angles				Sum of α angles			
Average α angle is							

Flow measurements were made in accordance with ESH-17-128.
Measurements by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

Calculations by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date

ESH-17 review and approval by:

_____ _____ _____ _____/_____/_____
Signature Print name Z-Number Date